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COLLIMATION
HALO 03
May 19-23, 2003

Comparison of the TESLA, JLC/NLC and CLIC Beam-Collimation System Performance

A. Drozhdin [4], G. Blair [6], L. Keller [5], W. Kozanecki [2], T. Markiewicz [5], T. Maruyama [5], N. Mokhov [4], O. Napoly [2], T. Raubenheimer [5], D. Schulte [3], A. Seryi [5], P. Tenenbaum [5], N. Walker [1], M. Woodley [5], F. Zimmermann [3]

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Goal of the work

- TRC attempted to verify readiness of the LC designs to deliver the Energy and Luminosity

- As part of this study,
  the Machine Detector Interface
  group of TRC, with help of
  the Collimation Task Force,
  reviewed performance of the
  collimation systems

The work presented is done by the Collimation Task Force group

Especially a lot of thanks to Sasha Drozhdin

~1/2 year study
Reported in
53 pages
10 Tables
40 Figures

LCC-0111
CERN-AB-Report-2003-006
CLIC Note 555, CERN
Fermilab-TM-2200
TESLA Report 2003-02
March 2003

Linear Collider Collaboration Tech Notes

Comparison of the TESLA, NLC and CLIC Beam Collimation System Performance

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March 2003

LC parameters

Table 1: LC parameters for 500 GeV c.m.energy.

parameter	TESLA	NLC	CLIC
Bunch population, $E+10$	2	0.75	0.4
Number of bunches per train	2820	192	154
Separation between bunches, ns	337	1.4	0.67
Repetition frequency, Hz	5	120	200
Average current (each beam), μa	45.1	27.6	19.7
Beam power (each beam), MW	11.3	6.9	4.9
Normalized emitt. x,y, mm·mrad	10, 0.03	3.6, 0.04	2.0, 0.01
Beta function at IP, x,y, mm	15.2, 0.41	8, 0.11	10, 0.05
Beam size at IP, x,y, (σ), nm	553, 5	243, 3	202, 1.5

- Assume (pessimistically) that we would need to collimate 0.001 of the beam
  - (despite that estimations predict much less)

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Beam Delivery Systems reviewed by the Collimation Task Force

NLC and CLIC use new FF with local chromaticity compensation

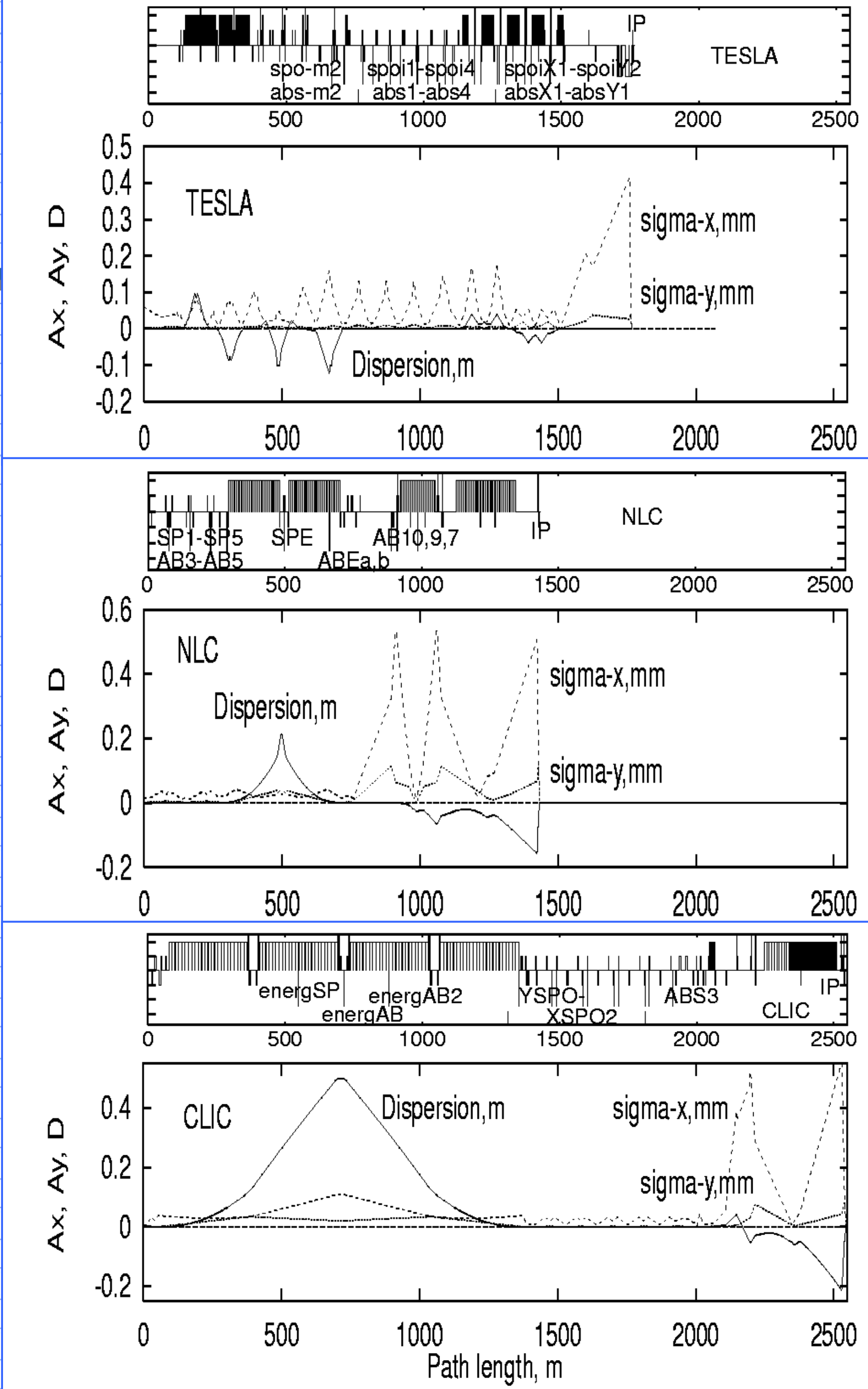
TESLA – traditional FF design

JLC/NLC and CLIC have crossing angle

TESLA – no crossing angle:
more complications for setting the collimation system

NLC:
Betatron coll. => Energy coll.

TESLA and CLIC:
Energy coll. => Betatron coll.



Simulation tools

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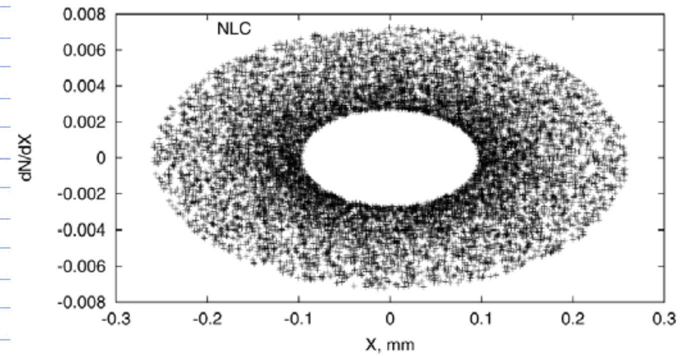
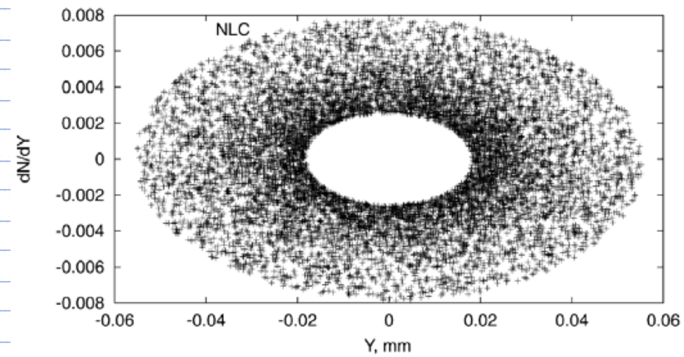
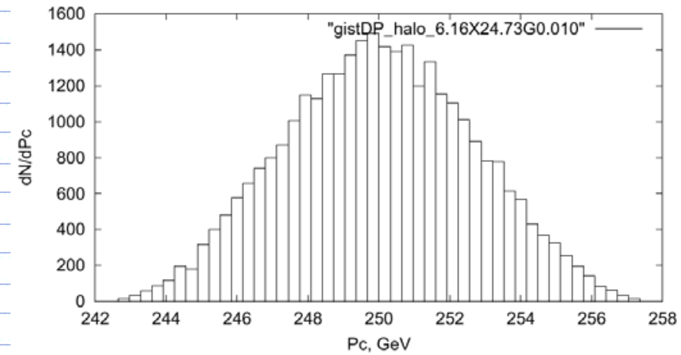
- Use STRUCT program
  - Cross check with TURTLE and Geant3
- Assume 0.001 of the beam in halo
- Distribute halo in 1/r manner surrounding the nominal collimation depth
  - Such distribution is more pessimistic than the flat one
- Gaussian in E

	TESLA	NLC	CLIC
Range of A_x/σ_x	7-18	6-16	5.7-14.2
Range of A_y/σ_y	40-120	24-73	54-162
Momentum spread $\sigma(dP/P)$, %	1	1	1
Typical number of rays	$5 \cdot 10^5$	$5 \cdot 10^5$	$5 \cdot 10^5$

Halo parameters used in simulations and example of initial beam distributions





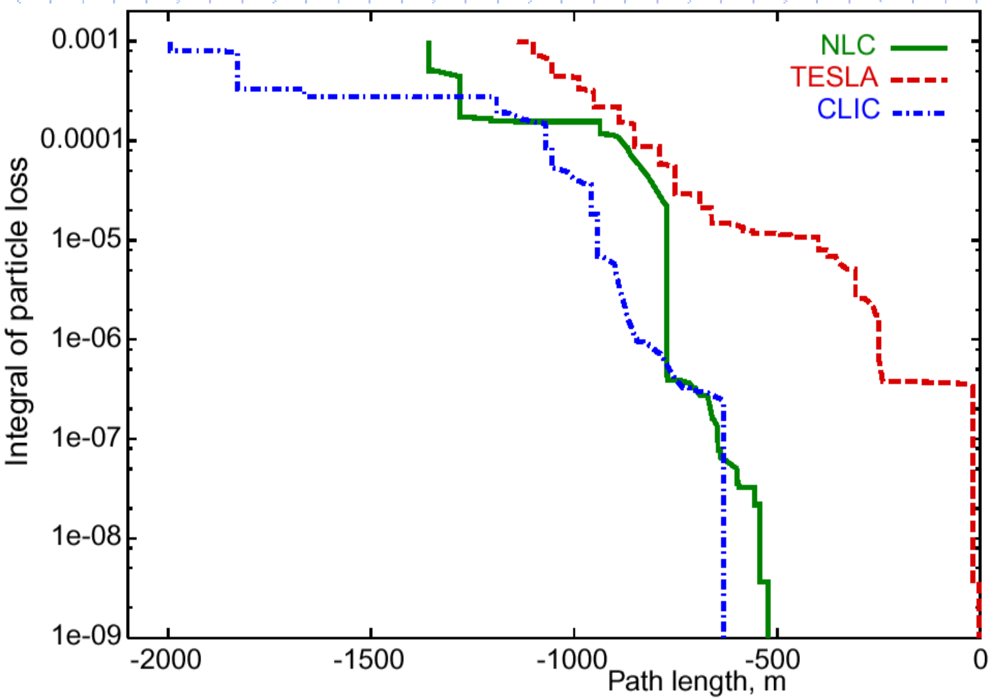


Methodology

- The effectiveness of the collimation system can be quantified in terms of:
  - the fraction of initial halo particles that survive (or are rescattered out of) the primary collimation system and hit secondary collimators or other aperture limitations closer to the IP
    - this is relevant when estimating muon backgrounds
- or
  - the number of halo particles that lie outside the collimation depth when they reach the final doublet
    - this is relevant when estimating synchrotron-radiation backgrounds

Performance in terms of halo particle losses along the beamline

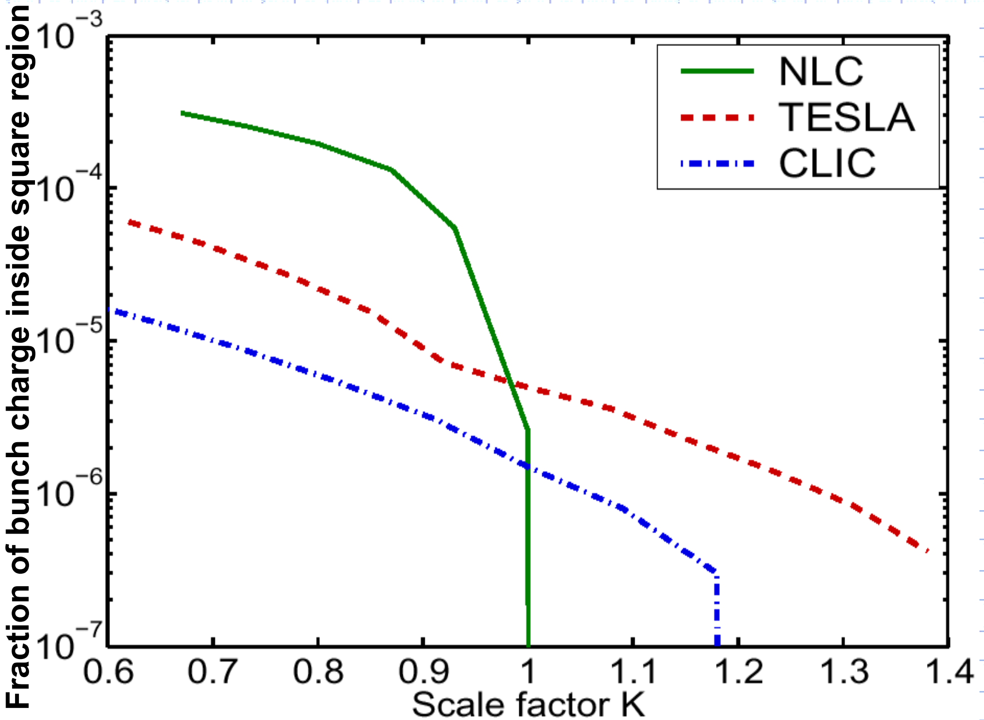
- NLC achieves a primary-collimation efficiency better than 1E-5
- CLIC collimation system achieves a primary-collimation efficiency of about 3E-4
  - For both in NLC and CLIC this efficiency number is a too crude figure of merit as losses vanish sharply after the collimation system. Further studies of muon reaching detector would give a better indication of performance

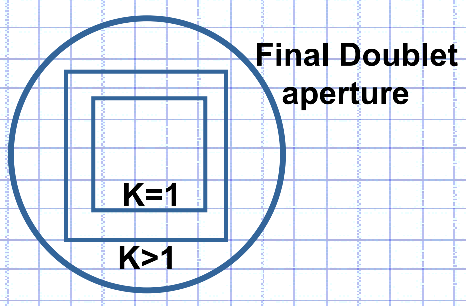


- In TESLA the loss rate in the secondary system amounts to about 1% of the initial halo population
  - The system, as currently designed, is not doing its job.
  - Studies of the reasons of such performance are ongoing
  - TESLA team is redesigning their FF using the new FF scheme

Performance in terms of halo size at the FD (SR on VX)

- In NLC, the edge of the collimation depth is sharply defined, and there are no particles outside collimation depth
- In CLIC, the edge is sharp too, but one need to iterate on desired collimation depth/gap settings
  - For both NLC and CLIC, the photons flux hitting SR masks seem to be small enough
- In TESLA, the boundary of the collimated halo is not visible
    - Charged-halo losses on the SR mask ~7400 particles/bunch
    - SR photons from the halo hitting detector masks: ~10^5 photons/bunch 3m downstream of IP and ~10^7 at 18m downstream





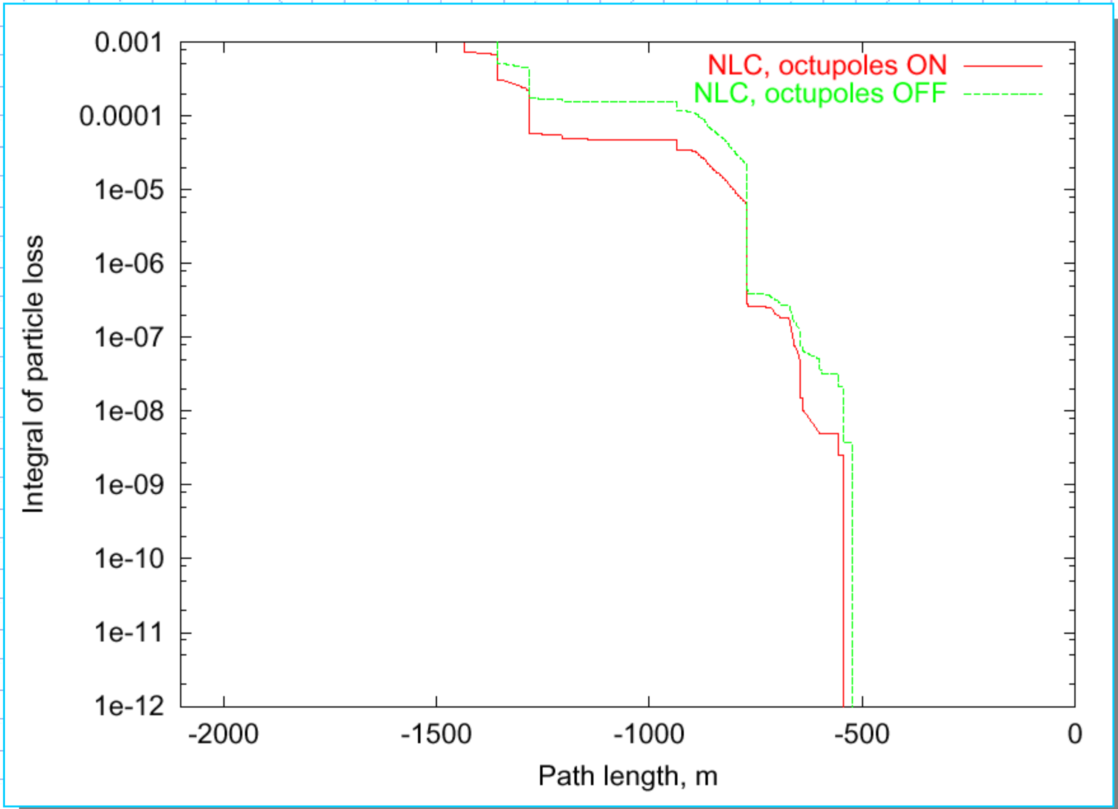
Conclusions for TRC

- Comparative studies of the performance of the post-linac beam-collimation systems in the TESLA, NLC and CLIC designs have shown that the performance of the systems as currently designed is not uniform across projects, and that it does not always meet all the design goals.
- As of this writing, the CLIC and NLC collimation schemes appear the most promising.
- Improvements of the TESLA collimation system are expected to result from the ongoing overhaul of their BDS design.
- Overall, the very existence of an acceptable solution suggests that achieving the required performance in future linear colliders is feasible.

Further work

- For TRC study, for the NLC system, considered only the more pessimistic case of Octupoles OFF. The Oct ON case has been recently verified and shows very good performance also
- TESLA team is working on improvements of BDS design
- So far considered ideal BDS optics. How does collimation performance change for non-ideally tuned machine?
- Understand effects of jittering beam.
  => jittering background?
- Would like to verify muon background and suppression by tunnel fillers using MARS simulations

NLC BDS with and w/o Octupole Doublets



With Oct ON the beam losses along the beamline behave nicely, and SR photon losses occur only on dedicated masks (gaps are +-0.6mm instead of +-0.2mm)

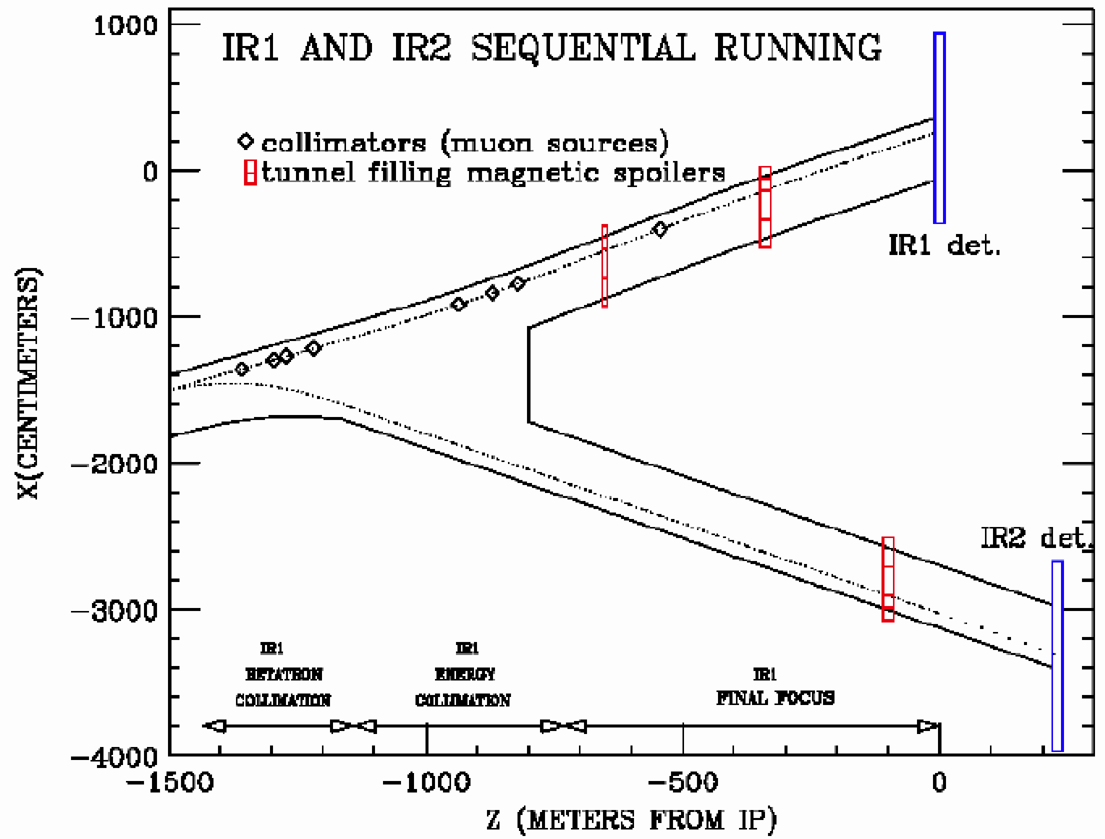
A. Drozhdin, et. al., LCC-118, SLAC, 2003, in preparation.

Performance of NLC BDS looks very good both with and without octupoles. The Oct ON case allow to open the collimation gaps and reduce the collimation wake fields to an acceptable level

Muons in NLC

Assuming 0.001 of the beam is collimated, two tunnel-filling spoilers are needed to keep the number of muon/pulse train hitting detector below 10

Would like to confirm these MUCARLO simulations with MARS



Conclusion

- This was a brief overview of Collimation Task Force work and further plans
- Basic conclusion is optimistic – a good collimation system looks feasible
- Next talks will give more details about the NLC systems design
  - For this workshop, would be useful to discuss, for example:
    - Basic assumptions on collimation material survivability
      - » Can we do more tests, use available data?
    - Design of collimations (e.g. consumable spoilers)
      - » Ways to improve, alternative schemes?
      - » Material choice (e.g. Be is OK if also activated?)
    - Beam tests
      - » Test/Use of NLC consumable prototype at LHC?
      - » E.g., use of SLAC beam for LHC-needed tests?
      - » Can we use Octupole Doublets tail folding, e.g., in SNS?
    - Use of codes and completeness of material interaction physics
      - » Use of MARS for NLC BDS and Detector
    - Dynamics in LC linac
      - » Are there any mechanisms of halo formation that we are missing?